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FORAGE PRODUCTION AND UTILIZATION IN FEEDING DAIRY CATTLE

By R. E. Hodgson, Chief, Dairy Husbandry Research Branch,
Agricultural Research Service 1/

Introduction

Modern concepts of livestock production revolve around growing and efficiently using farm-produced forage. The place of forages in the farm management scheme, in good land use practices, and in land conservation is established beyond doubt. Forages grown on efficiently managed land can be made to yield large amounts of essential feed nutrients comparable to those of other crops and at lower costs. On the other hand, poorly managed forage crops can be low yielding and expensive feeds. Unfortunately, too much of the land in forages is not as productive of feed nutrients as it could be, and there is opportunity here for farmers to increase their livestock feed supply.

Historical Increase in Yields of Feed Crops

The researcher, the extension worker, and the farmer have not given as much attention to forage crop production as they have to their other crops. This is indicated in table 1 which summarizes the per acre yield of certain feed crops and the percentage increase in yield from 1933-42 to 1954. Note that the increase in yields of forage crops over this period has lagged far behind that of the grain crops. Corn silage no doubt has benefited from the introduction of hybrid corn. We need in forage crops something like the developments in corn where hybridization, heavy fertilization, and improved cultural methods have brought about tremendous increases in yields in less than two decades.

1/ Paper presented at a Joint Symposium on Forage Utilization by Dairy Cattle at the Annual Meeting of the American Dairy Science Association, East Lansing, Mich., June 22, 1955.

Table 1.- Average per acre yield of feed crops in the United States for specified periods 1/

Crop	1933-42 average	1949	1954	Increase over 1933-42	
				1949	1954
	Pounds	Pounds	Pounds	Percent	Percent
All hay	2,460	2,720	2,860	10.6	16.3
Alfalfa hay	4,060	4,460	4,300	9.9	6.0
Clover and timothy hay	2,380	2,460	2,860	3.4	20.2
Corn, silage	13,820	18,560	15,980	34.2	16.9
Corn, grain	1,450	2,178	2,150	50.2	48.3
Oats, grain	922	1,043	1,139	13.1	23.5
Barley, grain	1,070	1,157	1,370	8.1	28.7

1/ Adapted from reports on Agricultural Statistics 1954, USDA.

Dairy Cattle Use Large Quantities of Forage Efficiently

Cattle, by virtue of their unique digestive systems, are able to consume and utilize large quantities of forage. Thus it is possible to use the tremendous quantities of available forage in producing vital animal food products for our people and at the same time provide a market otherwise not available for the output of a significant part of our agricultural land that should be in grass.

Dairy cattle use large amounts of forage. More than 70 percent of their feed comes from this source. Recent statistics, as shown in table 2, indicate the major sources of feed for the different classes of farm livestock. It is estimated that in the year 1949-50 dairy cattle consumed 30.7 percent of the pasture, 81.3 percent of the silage, and 59.1 percent of the hay fed to all livestock.

Table 2.- Percentage of livestock feed supply coming from different sources 1949-50 1/

	Pasture	Hay	Silage and beet pulp	Concentrates	Other
	Percent	Percent	Percent	Percent	Percent
Dairy cattle	37.1	26.7	7.0	26.3	2.9
Beef cattle	66.1	14.7	1.7	15.0	2.5
Sheep and goats	82.9	9.5	0.7	5.1	1.8
Hogs	5.2	-	-	90.9	3.9
Poultry	2.5	-	-	97.0	0.5

1/ From Table 1, Statistical Bul. 153, USDA, 1955.

It is interesting to note geographical differences in the sources of feed for dairy cattle. This is summarized in table 3. The eleven East-North Atlantic States used relatively less pasture and more concentrates, especially formula feeds, while the dairy cattle in the fourteen Southern States obtained relatively more feed from pasture and less from hay.

Table 3.- Specified sources of feed for dairy cattle in different regions - 1940-50 1/ 2/

Region	Pasture	Hay	All concentrates	Formula feeds
	Percent	Percent	Percent	Percent
Eleven Northeast and North Atlantic States	25.2	32.5	32.0	22.3
Eight Midwest States	36.1	26.3	27.1	3.1
Four Northern Great Plains States	37.5	33.0	21.5	1.0
Fourteen Southern and Southwest States	49.4	18.7	25.4	11.1
Eleven Mountain and Pacific States.	33.2	35.1	16.0	6.6
United States	37.0	27.0	26.0	8.0

1/ From Table 7, Statistical Bulletin 153, USDA, 1955.
2/ Data do not include miscellaneous feeds such as stover, byproducts, etc.

Forage Crops Are Cheap Source of Feed Nutrients

Even though dairy cattle obtain more than 70 percent of their feed from forage, there is opportunity to place more dependence on this type of low cost feed for milk production. This also offers the greatest opportunity to lower the cost of milk production. Recent data, table 4, show that the cost of producing 100 pounds of total digestible nutrients (TDN) in pasture is only about two-thirds as much as for hay, half that for corn silage, and about one-third of that for wheat grain.

Table 4.- Cost of 100 lbs. of total digestible nutrients 1/

Orchard grass-ladino pasture in rotation with crops	$ 0.69
Bluegrass-white clover pasture well managed	0.71
Mixed hay	1.10
Corn silage	1.35
Wheat	2.56

1/ From ARS 52-2, 1954, USDA.

Pasture Yields Low - Can Be Increased

The average yield of pasture throughout the country is low and could be greatly increased through adoption of improved cultural and management practices. Department statistics (USDA Statistical Bul. 153, 1955) indicate that the average milk cow received about 1,300 to 1,400 pounds of total digestible nutrients from pasture in 1949-50. This is equivalent to about 1 1/4 tons of average hay or equal to the average acre yield for all hay. Thus it would require about 2 acres to support one standard cow day of grazing for a 180 day pasture season. Many research studies and farm examples indicate that most pasture land can be made to yield much more than this, and at a profit over increased costs.

One of the first jobs in better feeding of dairy cattle is to increase pasture production in all areas of the country. In this respect a big problem is to provide a more uniform supply of pasture feed throughout each day of the grazing season. The use of more legumes, heavier fertilization, supplemental irrigation, annual pasture crops, harvesting surplus pasture during the flush season and feeding it later as hay or silage when grazing is scarce, together with the best available methods of grazing management, all help to accomplish this. While we need much more research on the cultural and management aspects of pasture production and use, we now know enough to make significant progress in increasing yields. Greater efforts need to be made in applying the information at hand.

Forage Consumption Is Low and Should Be Increased

The most limiting factors in getting the greatest benefits from forage are (1) that too many cows are just not fed enough, and (2) that the quality of the forage is so poor that consumption is low.

An analysis that I recently made of data reported by USDA farm management specialists (Agri. Info. Bul. 86, 1952) of farming practices on family farms in the Northeast indicated that from 1940 to 1951 the amount of hay (equivalent) fed per cow per day gradually decreased from 20.5 to 19.2 pounds. This probably is a pretty good indication of the amount of forage that the average dairy cow consumes. On the other hand, the amount of grain fed per cow per year in this study increased in that time from 1,425 pounds to 1,912 pounds, and the TDN required for milk production calculated as coming from grain went up from 73 percent to 87 percent. In other words, in 1951 the forage provided for maintenance and only 13 percent of the milk yield of cows in these herds.

Factors Influencing Rate of Forage Consumption

We have had considerable research experience that shows us that cows will consume considerably more forage than the above indicated amounts. However, we do not know enough about all of the factors that influence how much

forage a cow will eat. The quality, which at best is an overall descriptive term, does influence consumption. We know cows will eat more high quality forage than they will low quality forage.

Table 5 summarizes some of the data that is in the literature on the average consumption of forage per unit of body weight by experimental cows when fed different amounts of grain. While undoubtedly differences in kinds and quality of forage were a factor causing variation in the consumption rates reported, the amount of grain fed had some influence. It does not appear, however, that feeding grain at the rate of 1 to 4 or 5 of milk or, for example, about 1 ton of grain per cow per year, would have much influence on materially reducing forage consumption. This would be especially true of high quality harvested forage or excellent pasture herbage. The optimum ratio of grain to milk to feed depends on a number of factors and is a question continually confronting the farmer. Under average or better conditions it would appear sensible and economical for farmers to provide adequate supplies of high quality forage fed to the limits of the cow's capacity to consume it, and then grain in addition at quantities that not unduly reduce forage consumption and stimulate enough more milk production to more than pay for the added grain.

Table 5.- Relation of rate of grain feeding to consumption of forage

Source of data	Consumption of hay equivalent per 100 pounds body weight daily							
	No grain	Ratio of milk to grain fed daily						
		1:6.0	1:4.0	1:3.8	1:3.3	1:3.0	1:2.6	1:2.2
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
USDA Tech. Bul. 1079 1/	-	-	-	2.5	-	-	-	-
USDA Tech. Bul. 610 2/	-	-	-	-	-	2.3	-	-
USDA Tech. Bul. 724 2/	2.7	2.2	-	-	-	-	-	-
USDA Tech. Bul. 815 3/	2.8	2.4	2.3	-	-	2.2	-	1.8
USDA Tech. Bul. 815 2/	-	-	1.9	-	1.8	-	1.8	1.8
Wash. Agr. Expt. Sta. Bul. 386 4/	2.9	-	-	-	-	-	-	-

1/ Alfalfa hay, alfalfa silage, corn silage.
2/ Alfalfa hay, corn silage.
3/ Alfalfa hay, corn silage, alfalfa silage, mangles.
4/ Alfalfa hay.

Relation of Forage Quality to Feeding Value

High quality in forage may be described by the following physical characteristics: (1) Evidence of early maturity; (2) leafiness (especially legume or legume-grass mixed forage); (3) soft and pliable, free from steminess; (4) green and bright in color; (5) relatively free from undesirable weeds and grasses; (6) free from dust and mold. In the absence of actual chemical and feeding tests to indicate nutritive values, USDA officials have utilized certain of these physical characteristics to classify hays into official U.S. grades to use as a guide in determining the quality of different hays. Classifying silages and pasture forage is more difficult, and satisfactory standards have not yet been established. There is need for further work in establishing simple and descriptive grade standards for all types of forage and to relate grades to feeding values. Some work is being done in this regard with hays.

Relation of U.S. Grade of Hay to Feeding Values

Table 6 summarizes a test comparing U.S. No. 1 alfalfa and U.S. No.2 alfalfa heavy timothy mixed hay using dairy heifers as experimental subjects. The No. 1 hay was quite superior in that it was consumed in larger amounts, produced greater gains and required less dry matter per pound of gain than the mixed hay.

Table 6.- Relation of quality of hay to consumption and gain in weight of dairy heifers 1/

Quality of hay	Hay dry matter consumed per day	Live weight gain per day	Dry matter consumed per pounds of gain
	Pounds	Pounds	Pounds
U.S. No. 1 alfalfa..	18.7	1.73	10.81
U.S. No. 2 alfalfa heavy timothy mixed	15.1	.91	16.59

1/ Gordon et al. Jour. Dairy Sci. 37, 9, 1116-1122. 1954.

Table 7 shows results of other experiments with heifers fed alfalfa and alfalfa grass mixed hays. Again the higher grade hays were of higher nutritional value as indicated by growth in heifers. Note the favorable relationship between the leaf content and daily consumption and gains as

well as the unfavorable relationship between fiber content and daily consumption and gains. All of these hays provided more protein than required by the heifers. From these results it appears that hays of higher grade, as indicated by higher leaf content and lower fiber content, are more acceptable and produce greater gains in heifers with lower feed requirements than lower grade hays.

Table 7.- Relation of grade, physical and chemical characteristics of hay to level of consumption and gain in weight of dairy heifers 1/

Kind and grade of hay	Leaf content	Protein content	Fiber content	Daily dry matter consumption	Daily weight gain
	Percent	Percent	Percent	Pounds/cow	Pounds/cow
Experiment I					
U.S. No. 2 green alfalfa 2/	37	18.8	30.3	17.9	1.75
U.S. No. 3 alfalfa	21	16.8	38.3	16.3	1.41
Experiment II					
U.S. No. 1 alfalfa	46	20.3	27.5	16.5	1.51
U.S. No. 3 alfalfa 2/	19	14.8	38.8	14.0	1.15

1/ Gordon et al. Jour. Dairy Sci. Sept. 1952.
2/ Light grass mix.

In experiments with milking cows, as shown in table 8, average grade No. 2 alfalfa did not appear enough better than a high grade No. 3 alfalfa to show a difference in feeding value. When U.S. No. 3 Lespedeza hay was compared with U.S. sample grade Lespedeza hay, the results, as shown in table 9, indicate that considerably more of the sample grade hay had to be fed to obtain about the same milk production as obtained with the No. 3 hay. On the basis of these results 4 tons of the No. 3 hay were equal to 5 tons of the sample grade hay. The sample grade hay contained considerable foreign matter and coarse material that was not eaten by the cows. This illustrates the point that high quality forage that will be eaten in large amounts must be relatively free from weeds, undesirable grass, coarse stems, etc.

Table 8.-Relation of quality of alfalfa hay to consumption and milk production in dairy cows 1/

Quality of hay	Leaf content	Green color reading	Dry matter: Protein	Dry matter: Fiber	Calculated TDN	Hay dry matter consumed daily	FCM produced daily	Hay dry matter consumed per pound milk
	Percent	Units	Percent	Percent	Percent	Pounds	Pounds	Pounds
U.S. No. 2 alfalfa..	26.3	48	16.8	34.4	54.9	27.9	31.0	1.20
U.S. No. 3 alfalfa..	18.6	45	15.3	38.2	51.5	26.3	29.6	1.10

1/ Unpublished data DHRB, USDA.

Table 9.- Relation of quality of Lespedeza hay to consumption and milk production 1/

Quality of hay	Feed consumption daily: Hay fed	Hay consumed	Dry matter consumed	Grain consumed	Daily loss of weight	Milk produced FCM daily	Dry matter consumed per pound FCM produced
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
U.S. No. 3 leafy, green	27.6	23.2	21.0	5.2	-.18	20.0	1.29
U.S. sample grade extra leafy, green	33.6	24.0	22.0	5.1	-.12	19.8	1.34

1/ Van Horn et al. Jour. Dairy Sci. 35, 6, 559-545, 1952.

Influence of Stage of Maturity on Yield, Quality, and Feeding Value of Forage

The stage of maturity at which forage is utilized has great influence on the yield and its digestibility and feeding value. This is illustrated by the data in table 10. As stage of maturity increased, the fiber content of the orchard grass increased and the protein content, protein and fiber digestibility, and the TDN content decreased. A hundred pounds of the mature hay contained only 86 percent as much TDN as 100 pounds of a grain mix, while the early cut hay contained 97 percent as much.

Table 10.- Relation of stage of maturity, composition, digestibility, and nutrient content of orchard grass hay (dry matter basis) 1/

	Protein		Fiber		Nutrient Content		Pounds grain mix to equal 100 pounds hay 2/
	Percent	Digestibility coefficient	Percent	Digestibility coefficient	Digestible protein	TDN	
1. Pasture -cut May 19	24.8	67	26.9	81	16.6	70.3	93.7
2. Early hay-cut May 31	15.8	63	28.2	77	11.0	72.9	97.2
3. Medium hay - cut June 14	13.0	59	31.8	71	7.7	67.4	90.0
4. Mature hay - cut June 27	12.4	59	35.0	68	7.3	64.5	86.0

1/ Adapted from Ely et al. Jour. Dairy Sci. 46, 4, 325, 1953.
2/ Grain mix considered to contain 75 percent TDN.

Harvesting hay in the early stages of maturity also produced greater yields of digestible protein and nutrients per acre. This is illustrated in tables 11 and 12 reporting results of a 3-year study on the yield and feeding value of alfalfa hay harvested at 3 stages of maturity. When these hays were fed to milking cows as the only feed, the production of milk per cow per day was greater and the hay required to support a cow and produce 100 pounds FCM was less for the initial bloom hay than for that cut at later stages. The calculated milk yield per acre of the initial-bloom hay was 20 percent greater than for the half-bloom hay and 63 percent greater than for the full-bloom hay. Much of this big difference was found to be due to the lower total seasonal yield of the hay cut in the later stages of maturity.

These and other available data clearly indicate that one good way for farmers to insure higher quality, nutritious feed with larger yields of digestible nutrients per acre is to harvest their forage crops in the early stage of maturity. Extension workers can well afford to emphasize the importance of this practice to farmers.

Table 11.- Protein content and yields of dry matter, protein and total digestible nutrients per acre of alfalfa harvested at initial, half, and full bloom stages (3 year average) 1/

Stage of maturity	Protein content	Dry matter digestibility 2/	Dry matter yield	Protein yield	TDN yield (calculated)	TDN content 2/
	Percent	Percent	Pounds	Pounds	Pounds	Percent
Initial bloom	18.2	77.7	7,896	1,427	4,660	59.0
Half bloom	18.3	77.1	7,778	1,381	4,413	56.7
Full bloom	15.7	75.4	6,061	977	3,269	53.9

1/ From USDA Tech. Bul. 739, 1940.

2/ Determined with sheep on the 1937 crop of hay and used for the average for the 3 years.

Table 12.- Comparative calculated milk production per acre of alfalfa harvested at three stages of maturity and fed to dairy cows 1/

Stage of maturity of hay	Average daily FCM produced	Average daily TDN required	Hay required for support of cow and 100 pounds FCM	Estimated yield of milk per acre
	Pounds	Pounds	Pounds	Pounds
Initial bloom	27.9	19.6	141.6	6,194
Half bloom	23.6	19.2	167.8	5,145
Full bloom	20.8	17.9	176.6	3,814

1/ Adapted from USDA Tech. Bul. 739, 1940.

Relation of Methods of Harvesting and Storage to Losses and Changes in Feeding Value

Forages intended for barn feeding, even though they are properly grown so that they are high yielding and nutritious and are cut at the proper stage of maturity, still must face the hurdles of harvesting and storage before they get to the cows. The harvesting methods used and the weather conditions prevailing during harvesting have much to do with the appearance, character, quality, and nutritive value of the preserved forage. With the changes that take place in these characteristics of forage during harvesting and storage go variable losses in dry matter and feed nutrients, which are not so apparent to the average person. The best way to harvest and store forage

presents a critical problem to every dairyman, especially those in the humid and semi-humid regions.

Only recently, I believe, have we become fully aware of the high losses in feed that occur from harvesting and storing forage. Recent Beltsville research on this problem is summarized in table 13. The losses resulting from harvesting forage from the same fields by four different methods were carefully measured over a 6-year period. The high losses of feed nutrients observed are rather typical, I believe, of what is happening when harvesting forages in the humid regions. The losses from field curing were staggering. Artificial dehydration (using a portable rotary drum drier) appeared slightly the most efficient, but at present this method is not very practical. The silage method appeared the most practical and next most efficient. Barn drying, using heat, closely approximated the silage method, but it usually is difficult to provide a source of heat with most farm installations. The silage method reduces losses by one-third to one-half compared with field curing.

Table 13.- Losses of dry matter and feed nutrients from alfalfa mixed forages harvested and stored in different ways 1/

	Field-cured hay		Barn-finished hay		Silage	Artificial dehydration
	Rained on	No rain	No heat	Heat		
Dry matter, percent	36.6	21.0	19.0	15.2	16.8	9.7
Protein, percent	46.1	27.7	24.0	21.3	16.9	18.2
Carotene, percent	99.1	96.8	93.7	89.6	80.9	76.5
TDN, percent	42.1	25.5	24.0	20.5	19.5	13.1
Net energy, percent	47.2	29.6	28.6	25.5	19.5	18.1

1/ Adapted from table 69, USDA Tech. Bul. 1079, 1954.

The comparative yields of protein and digestible nutrients available for feeding from a standing crop yielding 2 1/2 tons of dry matter per acre have been estimated in table 14. The saving in digestible protein and TDN, when using alternatives to field curing, point up the opportunities for farmers to increase the efficiency of their feed production methods and reduce the purchased feed bill. To illustrate, when figured on a grain replacement basis, making silage compared to making field-cured hay saved as much TDN and more protein than is contained in 600 pounds of a 24 percent grain mixture.

Table 14.- Estimated comparative yields of feed nutrients from alfalfa mixed forage when harvested in different ways, and the grain sparing effect of improved harvesting methods 1/ 2/

Method of harvest	Per acre yield of feed			Increase over average of 1 and 2 3/			Grain mix equivalent 4/
	Protein	Digestible protein	Total digestible nutrients	Protein	Digestible protein	Total digestible nutrients	
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
1. Field-cured hay- rain...	571	393	1,795	-	-	-	-
2. Field-cured hay - no rain	715	505	2,336	-	-	-	-
3. Barn dried hay - no heat	753	536	2,347	110	87	281	375
4. Barn dried hay - heat..	784	562	2,463	141	113	397	530
5. Wilted silage	832	568	2,517	189	119	451	600
6. Dehydrated hay	803	547	2,703	160	98	637	850

1/ Adapted from tables 68 and 69, USDA Tech. Bul. 1079, 1955.
2/ Assuming a dry matter yield in each case of 2 1/2 tons per acre.
3/ Assuming that at least half the crop would be rained on during harvest.
4/ A 24 percent grain mixture containing 75 percent TDN.

As shown in table 15, the silage and artificial drying methods of harvesting were much more effective in preserving the leaves and the green color of the forage than were the various methods of making hay.

Grass Silage High in Feeding Value

Results like these are indicative of why we are giving so much attention to grass silage as a way of harvesting the forage crop. Comparative feeding tests on these same experimental forages, as indicated in table 16, show that when the different forages were fed at about the same level of dry

Table 15.- Effect of method of harvesting on leaf content and color of alfalfa forage 1/

Method of harvest	Leafiness		Color	
	As cut	After harvesting	As cut	After harvesting
	Percent	Percent	Percent	Percent
Field-cured hay (no rain).....	50	40	69	50
Field-cured hay (rained on)...	49	29	74	29
Barn-dried hay (heat).....	46	40	69	56
Barn-dried hay (no heat).....	47	42	66	51
Wilted silage.....	48	48	69	56
Dehydrated hay.....	47	48	71	52

1/ Adapted from Table 72, USDA Tech. Bul. 1079, 1954.

matter intake the silage was at least as palatable and effective in maintaining milk production as the dry forages, and better than the poorer grade field-cured hay that was damaged by rain. The silage made was of moderate moisture content, due to slight wilting of the forage. The forage was ensiled without a preservative and was of good quality.

Table 16.- Results of comparative feeding tests using forage harvested in different ways 1/

Items compared	Field-cured hay		Barn-dried hay		Wilted silage	Dehydrated hay
	Rained on	No rain	No heat	Heat		
Number trials	1	2	3	3	5	2
Milk production (FCM), av. daily, pounds.....	35.2	34.0	33.7	35.7	34.4	35.7
Ave. 30-day decline in production, percent.....	13.6	6.7	8.1	8.8	7.3	6.4
Change in weight, av. daily, pounds.....	- .19	+ .20	-.12	-.12	+.10	+.01
Dry matter consumed from experimental forage, av. daily, pounds.....	14.3	17.7	19.0	18.2	17.9	17.0
Total dry matter consumed, av. daily, pounds.....	30.2	31.4	32.7	33.1	32.1	31.6
Dry matter consumed per 100 pounds weight, experimental forage av. daily, pounds....	1.24	1.58	1.65	1.53	1.52	1.46
Total dry matter consumed per 100 pounds body weight, av. daily pounds	2.62	2.80	2.85	2.79	2.73	2.71

1/ Adapted from table 74, USDA Tech. Bul. 1079, 1954.

Need for Improving Methods of Making Grass Silage

While the silage method appears to be the best practical method of preserving nutrients in harvested forages, the total losses of dry matter under the best of conditions still average 15 to 20 percent. There is room for research to develop methods of ensiling that will preserve feed with smaller losses. It has been our experience that the moisture content of the forage ensiled in upright silos has considerable to do with the extent of dry matter and nutrient losses. This is indicated in table 17 for a total of 24 tests. Other results, even where chemicals or molasses preservatives have been used in forage of different moisture content, show that losses are invariably higher in the high moisture silage.

Table 17.- Dry matter losses in making grass silage at Beltsville[1/]

Material	Structure	Average depth of fill	Number trials	Average moisture	Total dry matter loss
		Feet			
Alfalfa, partly dried...	14' upright	34	2	49	13.0
Alfalfa, wilted.....	" "	34	2	63	8.4
Grain, wilted.....	" "	44	1	66	14.3
Alfalfa, partly dried...	10' upright	25	3	41	11.0
Alfalfa, wilted.....	" "	25	9	64	12.0
Alfalfa, molasses added.	" "	23	2	66	13.4
Soybeans, wilted.....	" "	24	3	69	14.8
Soybeans, fresh.....	" "	24	2	74	22.2
Orchard grass.....	15' snow fence	18	1	63	28.9
Pasture grass.....	" " "	18	1	67	30.1
Oats 2/.....	" "	18	1	68	21.1
Oats, wilted.....	" " "	14	1	59	33.6
Pasture grass 3/.....	10' x 15' stack	10	1	65	25.9

1/ Adapted from USDA BDIM-1042, 1949.
2/ Top weighted.
3/ Dirt covered.

A small amount of work has been done also with forage ensiled in snow fence structures and with a pit stack. The dry matter losses from storage in these structures average higher than with the upright silos.

Bunkers and Trenches for Grass Silage

Considerable research is being directed at storing hay crop forage in trench and bunker-type silos. Farmers are taking up this method of making grass silage to an increasing extent. While these types of storage have a number of appealing advantages, there is little information available on the input-output relationships compared to upright silos. Earlier work in Washington State (Wash. Agr. Expt. Sta. Bul. 348) with earth covered stack silos showed a recovery in good silage of 70 to 80 percent as much as obtained with the upright silo. Dry matter losses in the stacks averaged 31 to 35 percent. For each 100 pounds of dry matter ensiled, an estimated 40 pounds of TDN were recovered for feeding in the stacks, compared with 42 pounds for the upright silos. The forage used in these tests had a moisture content of about 75 percent when ensiled.

On the basis of our all too limited experience at Beltsville in making grass silage under a variety of conditions, and when so-called preservatives have not been used, we have estimated the minimum losses of dry matter resulting from ensiling forage of different moisture content and stored in different kinds of structures. These estimates of losses from various sources are summarized in table 18. Losses of dry matter of 25 to 30 percent or higher are not much better than for making hay. If newer type storage structures are to be successful, they should do a better job of preserving dry matter and feed nutrients than field curing.

More research is needed to determine the efficiency of the bunker, trench and stack type silos compared with upright silos and to develop methods of storages with minimum amounts of loss of feed nutrients.

Factors Affecting Palatability of Grass Silage

If we are to place more emphasis on forage in the ration and at the same time place more dependence on grass silage instead of hay, the silage must be of good quality and palatable so that cows will eat it in large amounts. Our knowledge of what constitutes a highly palatable silage--one that cows like and will eat a lot of--is limited. The strong odors of some silages do not seem to affect the cows as much as they do people. Our experience tells us that cows and heifers will consume more dry matter from silage with a relatively low moisture content than from silage of high moisture content, ensiled with or without a preservative. Table 19 summarizes some of our information on this point. This, it seems to me, is a compelling reason, among several others, for putting up silage with a moderate moisture content, 63 to 70 percent.

Table 18.- Estimate of minimum dry matter losses in forage stored as silage at different moisture levels 1/

Kind of silo, and moisture content of forage as stored	Dry matter losses					
	Surface spoilage 2/	Fermentation 3/	Seepage	Total silo losses	Field losses	From cutting of crop to feeding
	Percent	Percent	Percent	Percent	Percent	Percent
Conventional tower silos:						
85 percent...	3	10	10	23	2	25
80 percent...	3	9	7	19	2	21
75 percent...	3	8	3	14	2	16
70 percent...	4	7	1	12	2	14
65 percent...	4	8	0	12	4	16
60 percent...	4	9	0	13	6	19
Gas-tight tower silos:						
85 percent...	0	10	10	20	2	22
80 percent...	0	9	7	16	2	18
75 percent...	0	8	3	11	2	13
70 percent...	0	7	1	8	2	10
65 percent...	0	6	0	6	4	10
60 percent...	0	5	0	5	6	11
50 percent...	0	4	0	4	10	14
40 percent...	0	4	0	4	13	17
Trench silos:						
85 percent...	6	11	10	27	2	29
80 percent...	6	10	7	23	2	25
75 percent...	8	9	3	18	2	20
70 percent...	10	10	1	21	2	23
Stack silos:						
85 percent...	12	12	10	34	2	36
80 percent...	12	11	7	30	2	32
75 percent...	16	11	3	30	2	32
70 percent...	20	12	1	33	2	35

1/ Conservative estimates for careful filling methods and good drainage based on 6 months of storage. Plastic caps or other good covers will reduce top spoilage. Poor compacting and sealing of the silage and excessive rainfall or melting snow on uncovered trenches and stacks will increase losses. From BDI-Inf. 149, 1953.

2/ Includes side and end spoilage in trenches and stacks.

3/ Allowance made for some heating and flake mold at the lower moisture levels.

Table 19.- Relation between the moisture content of silage and the amount of silage dry matter consumed by dairy cows 1/

Crop harvested	Moisture content of silage	Dry matter eaten per 100 lbs. of live weight per day
	Percent	Pounds
Orchard grass:		
First cutting (boot stage):		
Fresh green	79.7	1.36
Wilted	66.9	2.00
Second cutting (early hay stage):		
Fresh green	71.8	2.08
Fresh green + 5% dry grain	69.7	2.21
Wilted	59.5	2.11
Alfalfa:		
First cutting (1/10 to 1/4 bloom):		
Fresh green	77.9	1.23
Wilted	72.7	1.94
Wilted	65.6	2.34
Half-dry 2/	45.7	2.52
Soybeans:		
First pods forming (dry season):		
Fresh green	74.1	1.52
Fresh green + 10% dry grain	69.9	2.19
Wilted	58.1	1.85

1/ From Beltsville experiments in 1950-52, reported in BDI-Inf. 149, 1952
2/ In gas-tight silo; no mold.

Getting More Milk from Forage

When a farmer has developed on his farm an adequate supply of high-quality, palatable forage that is made available to his herd with a minimum of loss of feed nutrients, he has the basis for an adequate economical dairy ration. He should then, under most conditions at least, adjust the size of his herd to fit the forage supply with each cow provided with all she will eat. Grain should be added to the ration to get extra milk insofar as it is economical and does not materially reduce forage consumption.

This does not appear to be the way farmers have been feeding their herds during the past two decades. Department reports indicate

that since 1935 the amount of grain fed per cow per year has increased from 943 pounds to 1,739 pounds in 1954. The pounds of grain fed per 100 pounds of milk produced have increased from 22.5 pounds to 30.0 pounds. This means that a proportionately smaller amount of the nutrients required for milk production is coming from forage. The practice of feeding more and more grain, while it is an easy way to increase milk production, is adding to the cost of milk production because nutrients are more expensive in grain than in home-produced forage. This trend can be checked by producing more and better forage. For example, table 20 shows how forage of varying TDN content can provide nutrients for greater milk production with the same intake of forage. The TDN in forage, as was shown, can be built up by harvesting at a more immature stage and with small losses, thus insuring high quality.

Feeding High Levels of Forage Throughout the Lactation

Roughage with a higher TDN content than the average will be consumed in larger quantities in relation to body weight than forage of average TDN content. Table 21 has been developed to show the contribution that forage can make to the maintenance and production of a cow during a 12-month period. This example cow is between 2 and 3 years old and produces 10,000 pounds of 4 percent F.C.M. in a 10-month lactation. The live weight and milk production curves are developed from available standards. In one case she consumes high-quality forage (hay equivalent) containing a TDN content of 55 percent at the rate of 2 1/2 pounds daily per 100 pounds body weight per day throughout the year. In another she consumes good quality forage containing 50 percent TDN at the rate of 2 1/2 pounds daily per 100 pounds body weight. In the third case she consumes average quality forage containing 50 percent TDN but at the rate of 2 pounds daily per 100 pounds body weight. Grain (containing 75 percent TDN) is fed to meet the balance of the requirements. Comparing cases 1 and 2 it would require 486 pounds more grain with the lower grade hay to obtain the same production, a nice saving for a higher quality hay. Comparing cases 1 and 3, it would require 1,620 pounds more grain but 2,187 pounds less forage to obtain the same production, and comparing cases 2 and 3, it would require 1,234 pounds more grain but 2,187 pounds less forage, still nice savings cost-wise.

Another point of interest concerning these three levels of forage feeding is the rate of grain feeding throughout the different months when it is needed to furnish the extra nutrients for milk production. The ratio of milk produced to grain needed widens during the latter part of the lactation period. This would be expected with the same level of forage consumption in relation to body weight. However, the usual recommendation made by many is to feed grain at the rate of 1 to 3, 1 to 4, or some such rate throughout the lactation. I wonder if this is a sound recommendation. Are our usual recommendations actually limiting forage

Table 20.- Roughage feeding schedule for producing dairy cows

Daily consumption of total digestible nutrients	Amount of hay (or equivalent as silage or pasture) needed to meet the nutrient requirements of cows when it contains the following percentage of total digestible nutrients 1/ 2/			Amount of milk of indicated fat content cows of different weights should produce from this amount of TDN 3/		
	50 4/	55 5/	60 5/	900 lbs. 5% test	1,000 lbs. and 4% test	1,200 lbs. and 3.5% test
Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
12.....	24	22	20	13	12	8
14.....	28	26	23	18	19	15
16.....	32	28	27	24	25	22
18.....	36	33	30	29	31	28
20.....	40	37	33	35	37	35

1/ 3 pounds of corn or grass silage can be substituted for each pound of hay.
2/ If this amount of hay is not available or the indicated amount is not consumed by cows, 0.6 pound of concentrate can be substituted for each pound of hay.
3/ For production above these levels, feed concentrates at the rate of 2.5 pounds daily for each 5 pounds of 5% milk; 2.2 pounds daily for each 5 pounds of 4% milk; or 2.1 pounds daily for each 5 pounds of 3.5% milk.
4/ When the hay contains at least 6.0 percent of digestible protein, the requirements for this nutrient will be met.
5/ When the hay contains at least 7.0 percent of digestible protein, the requirements for this nutrient will be met.

consumption by cows in the later part of the lactation period? This may be something for us to think about.

This example is purely theoretical and is offered to provoke thought on how we can utilize forages to better advantage in feeding dairy cows. The level of grain feeding and the desirable proportions of grain to forage that should be carried in a good ration are something on which we need more information. The optimum situation no doubt will vary with individual cases. This much can be said for sure--the farmer who does a good job of producing and efficiently utilizing abundant supplies of high quality forage and has cows with high productive ability with an appetite for a lot of forage is in a good position to make a profit out of dairying under most conditions.

Table 21.- Estimate of nutrient requirements of a dairy cow and what proportion of these requirements forage might provide when of different nutrient content and when consumed at different levels of feeding

Days in month	Monthly weight 1/	Weight change	Average daily milk yield	Average daily TDN required	Daily TDN furnished by 3 levels of feeding forage 1 2/	2 3/	3 4/	Grain feeding rate needed to provide balance of nutrients 5/ 1	2	3
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds			
31	1,197	47	0	14.9	16.7	14.9	12.0	0	0	.5
31 6/7/	1,244	-126	40	16.1	17.1	15.6	12.4	3.3	3.3	3.3
28	1,118	- 8	48	23.5	15.4	13.8	11.2	4.1	3.7	3.0
31	1,126	19	45	25.6	15.5	14.0	11.3	3.3	3.0	2.3
30	1,145	23	41	25.0	15.7	14.3	11.5	3.3	3.0	2.3
31	1,168	19	37	23.4	16.1	14.6	11.7	3.8	3.2	2.4
30	1,187	18	34	22.5	16.3	14.8	11.9	4.1	3.3	2.4
31	1,205	16	31	21.6	16.6	15.0	12.1	4.6	3.4	2.5
31	1,221	16	27	20.2	16.8	15.2	12.2	6.0	4.5	2.7
30	1,237	21	23	19.7	17.0	15.4	12.4	6.0	4.0	2.4
30	1,258	28	18	19.1	17.3	15.7	12.6	7.0	4.0	2.0
31 7/	1,286	-	16	12.8	17.7	16.0	12.9	0	0	0

1/ Standard weight curve for 2-3 year old Holstein cow - USDA Tech. Bul. 1099, Table 15, 1954.
2/ Forage containing 55 percent TDN fed at rate of 2 1/2 lbs. daily per 100 lbs. weight.
3/ Forage containing 50 percent TDN fed at rate of 2 1/2 lbs. daily per 100 lbs. weight.
4/ Forage containing 50 percent TDN fed at rate of 2 lbs. daily per 100 lbs. weight.
5/ Pounds of milk per pounds of grain daily.
6/ Cow calved on 12th of month, 15 days grain feeding at 12 pounds daily; 126 lbs. weight loss attributed to calving.
7/ Milked for 15 days.

Feed requirements for year at 3 levels of forage feeding

Feeding level.....	1	2	3
Forage.....	10,945 lbs.	10,945 lbs.	8,758 lbs.
Grain.....	2,368 "	2,854 "	4,088 "

Some Additional Research and Educational Needs

In this discussion I have indicated a number of problems on which we need more research information. In addition, I think we must recognize that if the farmer is to materially reduce his costs of milk production he must have more information to help him produce more adequate supplies of high quality forage, both pasture and harvested roughage. Such information needs to come from soils, agronomy and engineering research, as well as from husbandry and management research.

There is great need for more information on pasture production, management, and utilization to improve the milk yields per acre of this important crop.

More work is needed in various regions on the efficiency of harvesting and storage of forages and on developing faster, cheaper, and easier ways of conserving larger amounts of the nutrients in crops grown for feed purposes. In this regard additional basic research is needed on making grass silage, including chemical and bacteriological investigations relating to fermentation, and on input-output studies with grass silage made in various kinds of storage structures. More efficient, low-cost silo structures are needed. More work is needed on the input-output relationships with cows fed different kinds of forage and fed at different rates in relation to grain. Better physical criteria are needed to indicate the quality and feeding value of all types of forages.

A most important problem yet needing a solution is the determination of energy values of forages so that more accurate estimates of the real feeding value of forages can be had than is now possible by the TDN method. Related to this is the need for additional research on the composition and digestibility of important constituents of forage feeds in order to develop more precise and descriptive information on the value of these feeds.

Another line of research deserving of attention is the development of strains of animals that are larger users of forage and that are more efficient in converting nutrients from these low-cost feeds to milk.

Finally, I see the need for a greatly intensified extension-education program for dairy farmers that will bring about a faster adoption of the useful information that is already known, as well as new information as it comes along, to improve the contributions that forages can make to efficient and low-cost milk production.